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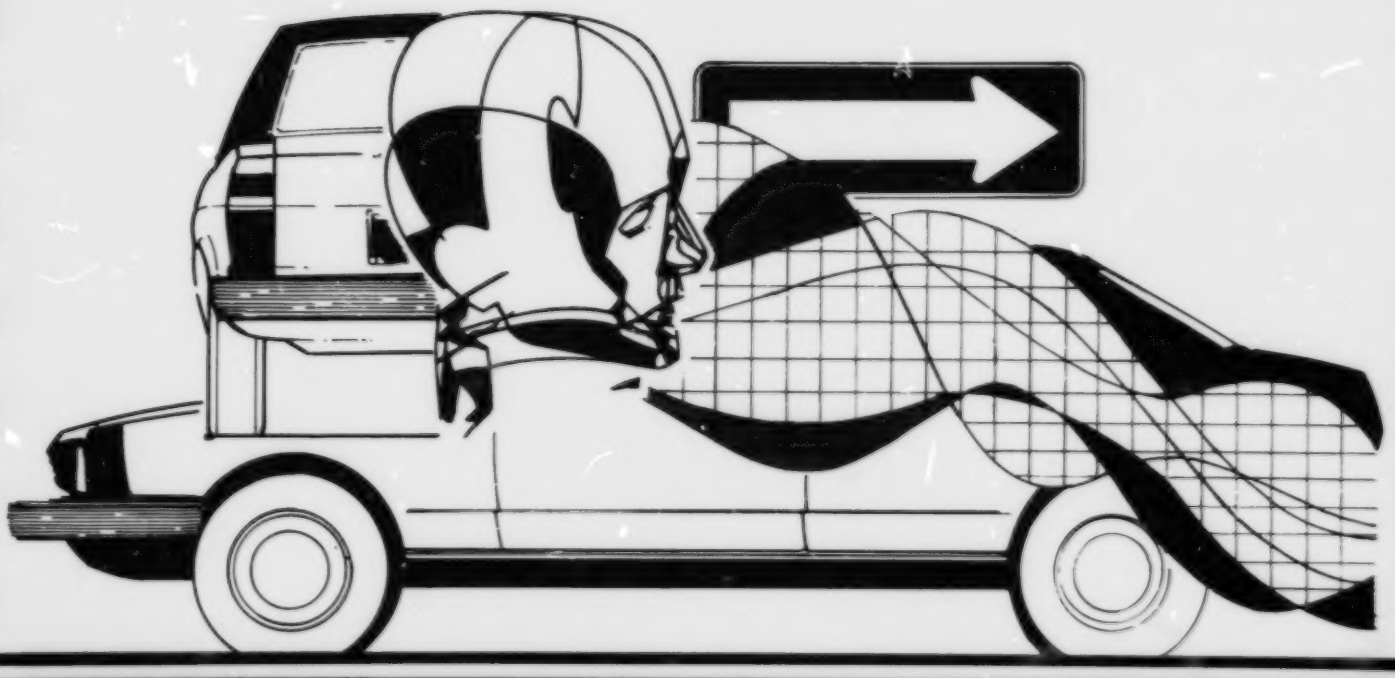
ANALYSIS OF THE RESULTS OF A SURVEY OF HEAVY-TRUCK BRAKES



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17. Abstract

The report presents the analysis of the results of a survey of heavy-truck brakes which took place in Canada in 1986. The survey, conducted at 11 weigh station in seven provinces, consisted of brake inspection and driver interviews. A total of 1511 vehicles were inspected. The report presents the fitment rates of front-axle brakes and automatic slack adjusters, and the condition of all the brakes inspected. Driver preferences and opinions regarding the use of front-axle brakes are also reported.

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ANALYSIS OF THE RESULTS OF A SURVEY OF HEAVY-TRUCK BRAKES

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May, 1988

SUMMARY

A survey of the utilization of heavy-duty truck brakes was conducted in Canada in 1986. The objective was to estimate the use of front-axle brakes and automatic slack adjusters on heavy trucks and to assess the operating condition of brakes on all axles.

A total of 1511 vehicles were surveyed at 11 weigh stations located in seven provinces. Measurements of push-rod travel were taken as an indication of brake adjustment. Besides brake inspections, interviews were conducted with drivers to assess their knowledge of truck braking in relation to the use of front-axle brakes.

Analysis of the survey results showed that 46.3% of the trucks inspected were not equipped with brakes on the front axles, while 1% of the vehicles had front brakes disconnected. The fitment rate of front-axle brakes was highest in Ontario (70.4%) and lowest in Alberta (35.5%). The percentage of front axles with maladjusted or inoperative brakes was highest in Manitoba (27.5%) and lowest in B. C. (5.3%). With respect to type of power unit, the front-brake outage was 16.9%, 11.5%, and 12%, respectively, for three-axle tractors, three-axle straight trucks, and two-axle tractors.

Of all the brakes inspected, 8.5% were maladjusted or inoperative, involving 24.9% of the vehicles in the survey. With respect to axle group, the brake outage was 16.5%, 5.4%, and 9%, respectively, for front axles, drive axles, and all other axles.

Of all the trucks surveyed, 6.1% (all articulated vehicles) had automatic slack adjusters (ASA) fitted to the brakes on one or more axles. Outage was 1.7% for brakes fitted with ASA, but 8.8% for brakes without ASA.

Some 72% of the drivers interviewed preferred driving a heavy truck without front-axle brakes. When asked to cite disadvantages, 53% of the drivers expressed the opinion that front brakes were most undesirable in rain or on wet road, but 32% failed to provide a plausible reason against their use. When asked to cite advantages, 44% of the drivers replied that front brakes would shorten stopping distances, while 52.9% could not give a reason in favour of their use.

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1. INTRODUCTION

1.1 Purpose of Study

To obtain information necessary for assessing the safety benefits of front-axle brakes and automatic slack adjusters, the Vehicle Systems Division of Transport Canada's Road Safety Directorate in 1986 conducted a national survey of the utilization of the two types of equipment. The field work, carried out at selected provincial weigh stations by a consulting company under contract with Transport Canada, involved two activities: (a) a vehicle inspection to determine the fitment rates of front-axle brakes and automatic slack adjusters and to assess the condition of all brakes on the vehicle; (b) a driver interview to elicit the attitude of the truck driver toward the use of front-axle brakes and to assess his knowledge of, and views on, particular aspects of truck braking.

The interview also contained many questions bearing upon the driving behaviours and characteristics of heavy-truck drivers. A report on this aspect of the study has previously been published.[1]

The present report contains the results of the analysis of the data relating to truck brakes and drivers' opinions on the use front-axle brakes.

1.2 Background

Heavy trucks, buses, and trailers in North America are typically equipped with air brakes. In Canada, air brakes on new vehicles must comply with Canada Motor Vehicle Safety Standard (CMVSS) 121. The Standard deals primarily with the generation and holding of air pressure in the brake system, and the fitment of service brakes, parking brakes, and emergency brakes. In the U.S., similar but more stringent requirements for air brakes are stipulated in Federal Motor Vehicle Safety Standard (FMVSS) 121. One major difference between the two standards is that FMVSS 121 requires brakes on the front axle of all trucks, whereas CMVSS 121 does not.

In Canada, all provincial motor-vehicle regulations require brakes on every wheel of a two-axle vehicle. However, except in Manitoba and P.E.I., any vehicle with three or more axles is allowed to have brakes on only two axles. Although both Manitoba and P.E.I. have regulations requiring brakes on every axle of a vehicle, these regulations are generally not enforced.

When the survey described in this report was begun, front-axle brakes were commonly deleted from three-axle tractors in Canada. Now, however, most if not all truck manufacturers have ceased to delete front-axle brakes, regardless of the purchaser's wishes.

Where front brakes are fitted, they are sometimes disconnected or otherwise disabled. It also remains common practice to install automatic or manually controlled pressure-limiting valves in the lines to the front brakes.

These practices have arisen principally from drivers' fears of losing steering control if front-wheel lockup occurs during braking. Unfortunately, the absence of fully effective front-axle brakes commonly causes rear-wheel lockup to occur prematurely during braking. A vehicle with

its front wheels rolling and its rear wheels locked is both unstable and unsteerable. The use of brakes on all axles produces a more balanced distribution of retardation forces during braking. Moreover, tests have repeatedly shown that a vehicle in motion will continue to travel straight ahead when only its front wheels are locked. However, it will become directionally unstable if its rear wheels are allowed to lock first. The instability is generally exhibited by the tendency of the vehicle's rear end to swing out. In the case of a tractor pulling a trailer, jackknifing could occur if the drive wheels are locked, and lockup of the trailer wheels could result in trailer-swing. These two types of instability are common among tractor-trailers in emergency braking.

The advantages of having brakes on all axles of a heavy truck have been demonstrated in various field tests in recent years.[2,3,4,5] These tests, conducted by Transport Canada and the U.S. National Highway Traffic Safety Administration (NHTSA), have shown that a truck with front-axle brakes produced shorter stopping distances and fewer unstable stops than one without front-axle brakes. These advantages definitely have a very strong safety implication, although real-world accident data do not readily yield the extent to which truck accidents are reducible by the use of front-axle brakes. It can be argued, however, that any significant improvement in the braking system of a vehicle obviously has a potential for reducing accident risk. This is therefore the basis on which changes to CMVSS 121 to require brakes on the front axle of every heavy truck are being considered.

Another consideration for brake-system improvement is the use of automatic slack adjuster (ASA). This safety feature is a self-adjusting mechanism that keeps the push-rod travel within acceptable range and limits the increase in brake chamber stroke caused by lining wear. The ASA

therefore reduces the incidence of maladjusted brakes and maintains the effectiveness of the braking system. Vehicle tests in the U.S. have shown that trucks with brake chamber stroke beyond that at which the manufacturer recommends re-adjustment produced 25% to 76% longer stopping distances than the same trucks with brakes fully adjusted.[6,7] The incidence of poorly adjusted brakes could be reduced by the use of effective automatic slack adjusters. However, automatic slack adjusters are not commonly used on heavy trucks. Early designs of ASA had a major problem of over-adjustment, caused primarily by extreme variations in operating and climatic conditions. More reliable ASA have emerged in recent years, and are now gaining wider acceptance by fleet operators. It remains to determine to what extent ASA are being used to serve the trucking community in Canada.

2. METHODOLOGY

2.1 Technique of Sampling Vehicles

Lack of reliable information regarding the population of commercial trucks by configuration in Canada made it impossible to develop an unbiased probabilistic sampling plan for the vehicles of interest in the study. Therefore, in the absence of such plan, the Vehicle System Division decided to adopt the relatively simple and convenient approach of conducting the survey at provincial weigh stations. Loaded commercial trucks are required to submit to checks for weight violation at the weigh stations whenever they are opened.

However, this approach entails three disadvantages. First, because the trucks sampled in the survey were not selected at random from all those operating on the highways, no estimates of sampling error of the results can be made. Second, because trucks not operating on main highways were excluded, the sample is not representative. Third, since warnings passed via citizen band radios probably induced some drivers to re-route trucks with poorly adjusted brakes to other roadways in order to by-pass inspection, the sample is likely biased toward trucks with better brakes. Nevertheless, sampling vehicles at the weigh stations is an inexpensive way of obtaining a convenient sample of heavy trucks.

This technique of sampling vehicles was made possible only with the agreement and co-operation of the provincial authorities. In consideration of the economics of the study, only ten locations from seven provinces were initially selected for the survey. Table 1 is a list of the survey sites, two from each of the three most populated provinces (Ontario, Quebec, and B.C.), and one from each of four other provinces (Alberta, Saskatchewan, Manitoba, and New Brunswick). These locations were chosen mainly on the

basis of two requirements: high traffic volume and long hours of operation of the weigh station. A sample size of 1500 vehicles was projected for the study, with about 150 vehicles to be surveyed at each site during a one-week period.

TABLE 1
SURVEY SITES

Site	Date (1986)	No. of trucks surveyed
Woodbridge, Ontario	June 9 - June 13	110
Oakville, Ontario	June 16 - June 20	153
Prince George, B. C.	June 23 - June 27	154
Kamloops, B. C.	June 30 - July 4	140
Regina, Saskatchewan	June 7 - July 11	155
Edmonton/Calgary, Alberta	July 14 - July 18	152
Winnipeg, Manitoba	July 21 - July 25	157
Lancaster, Ontario	Aug. 5 - Aug. 8	85
Vaudreuil, Quebec	Aug. 11 - Aug. 15	115
Beloeil, Quebec	Aug. 18 - Aug. 22	135
Fredericton, New Brunswick	Aug. 25 - Aug. 29	155

2.2 Collection of Data

The method of data collection used in the survey consisted of two activities: vehicle inspection and driver interview. These activities were carried out by a two-man team consisting of an interviewer and a mechanic supplied by the company contracted to conduct the survey. At several sites, provincial motor-vehicle inspectors were used instead of the contractor's mechanic.

The survey was aimed primarily at three-axle tractors towing one or more trailers. Such vehicles constitute a large majority of the heavy-truck population on provincial highways. The selection of vehicles, though not random, was quite arbitrary. As soon as one vehicle was processed, the next one arriving at the weigh station and meeting the selection criteria would be chosen. To intercept a truck for inspection, the interviewer from the survey team would approach the driver and explain the purpose of the survey. If the driver consented, he would then be asked to drive his vehicle around to a parking area behind the station, where the brake inspection and driver interview would proceed. For safety, wheel chocks were placed around the drive wheels of the vehicle to prevent it from moving. The interview took place with the driver sitting in the cab and the interviewer standing outside. Communication between the interviewer and the mechanic doing the inspection was made via an intercom device. This was necessary in order for the inspector to measure and record the push-rod travel at the brake chamber which required the driver to activate and release the brakes from his cab.

The form used for brake inspection is shown in Appendix A. Because of the time available for inspection, it was decided that in addition to the essential information on front-axle brakes and automatic slack adjusters, similar information on the brakes on all other axles should also be

recorded. Thus, space was provided on the vehicle form for recording the chamber size, stroke, and the operational condition of the brakes on both sides of each axle for a maximum of nine axles which was sufficient even for a triple unit (i.e. a tractor towing three trailers). Measurements of push-rod travel were made only for S-cam brakes, the most common type of air-brakes used on heavy trucks. For the uncommon air-brake systems such as air-hydraulic brakes, wedge brakes, and twin-wedge brakes, no stroke measurements could be made in the field. Determination of whether a brake was in adjustment was based on the specifications commonly used by the inspecting authority in most provinces.

Table 2 shows the adjustment specifications for various chamber sizes of truck brakes. On the vehicle inspection form, codes "I", "O", and "M" were used to represent, respectively, "in adjustment", "out of adjustment", and "marginal condition", the last being applied to cases where push-rod travel reached the maximum amount at which the brake should be readjusted (last column in Table 2).

The driver questionnaire used by the interviewer is shown in Appendix B. Developed by the Road Users Division in the Directorate, the questionnaire consisted of 31 questions and two observational check items (sex, and use of seat belt). While only a few of the questions were related to truck braking and the use of front-axle brakes, all others were incorporated for the interest of evaluating truck drivers' attitudes toward their job. These questions covered a wide spectrum of driving attributes including driving experience and training, ownership of the truck and trailer, trip length, pre-trip inspection, driving pattern, and drivers' perception on the use of stimulants and alcohol among truck drivers. The brake-related questions focused on drivers' awareness of fitment of front-axle brakes and pressure-limiting valve on their vehicles, and their preferences and opinions regarding front-axle brakes. A

TABLE 2
BRAKE ADJUSTMENT SPECIFICATIONS

Type	Effective Area (sq. in.)	Outside Diameter (in.)	Maximum Stroke (in.)	Maximum Stroke With Brakes Adjusted	Maximum Stroke at which Brakes Should be Readjusted (in.)
6	6	4-1/2	1-5/8	Should be as short as possible without brakes dragging	1-1/4
9	9	5-1/4	1-3/4		1-3/8
12	12	5-11/16	1-3/4		1-3/8
16	16	6-3/8	2-1/4		1-3/4
20	20	6-25/32	2-1/4		1-3/4
24	24	7-7/32	2-1/4		1-3/4
30	30	8-3/32	2-1/2		2
36	36	9	3		2-1/4

French version of the questionnaire was available for French-speaking drivers. The interviewer assigned by the contractor was fully bilingual.

Prior to the full-scale survey, a pilot test was conducted for two days at a weigh station near Casselman, Ontario. The purpose of the pilot test was to train the survey team and to evaluate the efficacy of the data-collection procedure and the utility of the survey forms. A provincial motor-vehicle inspector was on hand at the station to provide assistance for the initial set-up of the test. The pilot test showed that the average time required for processing a vehicle was 10 to 15 minutes. The duration of driver interviews was fairly consistent, but the time needed to complete the vehicle form depended on the number of axles on the vehicle.

The survey was conducted in the summer months of 1986, from June to August (Table 1 shows the dates of the survey at each site). The survey began in the province of Ontario, with supervision provided by the same provincial motor-vehicle inspector who had participated in the pilot test. He conducted all the work of vehicle inspection in Woodbridge, and a great bulk of it in Oakville. Provincial vehicle inspectors were also used in Alberta and Manitoba, as stipulated in the arrangement with the two provinces. In Alberta, the survey took place in two cities, Edmonton and Calgary. In Regina, Saskatchewan, three different weigh stations within the same vicinity were involved.

It should be noted here that, due to other work commitment, the contracting company's mechanic who had been involved in the pilot test was not available for the survey. The contractor called upon a substitute mechanic on short notice prior to the survey. His service did not begin until the second week of the survey in Ontario at the Oakville

site, where he acquired his training on the job from the provincial inspector.

Owing to operational problems encountered in the field, the number of vehicles inspected fell short of the target at several sites. A supplementary site (Lancaster, Ontario) was chosen for additional work to make up the total requirement. In all, a total of 1511 vehicles were surveyed at the 11 sites. Of all the drivers interviewed, only two refused to provide answers to the questionnaire.

3. RESULTS

3.1 Overview of the Vehicles Surveyed

Table 3 distributes the 1511 surveyed heavy trucks by province and by number of axles. Although the main emphasis was on three-axle tractors towing one or more trailers, the brake survey also included an arbitrary selection of 61 three-axle straight trucks and 27 two-axle tractors and semitrailers. The purpose was to determine if any of the front brakes on such vehicles were missing or inoperative. The articulated trucks with three-axle tractors shown in Table 3 accounted for 94.2% of the survey total. Also, almost 70% of the surveyed vehicles were five-axle tractor/semitrailers. For the vehicles having six to nine axles, exact configurations were not specifically coded on the vehicle form, although sometimes an A-train or B-train was indicated. Nor did the form differentiate among dolly axles, lift axles, and trailer axles. Hence, for example, a six-axle vehicle might have consisted of a three-axle tractor and a tri-axle trailer, or a three-axle tractor, a two-axle B-trailer, and a single-axle trailer. More configurations are possible for vehicles with more than six axles.

In the analysis that follows, brakes are divided into three axle groups: front axles; drive axles; and other axles, which include all dolly axles and trailer axles. Front-axle brakes are subdivided by three types of power unit: three-axle straight trucks; two-axle tractors; and three-axle tractors. The tabulations for brake condition apply strictly to S-cam brakes, the only type for which stroke measurements were recorded. For simplicity of discussion, brakes coded as "marginal" were deemed to be "out of adjustment" in that the stroke measured had reached the maximum amount at which brake adjustment was required.

TABLE 3
VEHICLES SURVEYED BY NUMBER OF AXLES

Number of axles	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	Total in Survey
3 axles[1]	11 (3.7)	7 (4.6)	1 (0.7)	1 (0.6)	41 (11.8)	0 (0.0)	0 (0.0)	61 (4.0)
4 axles[2]	3 (1.0)	2 (1.3)	3 (1.9)	2 (1.3)	1 (0.3)	1 (0.4)	0 (0.0)	12 (0.8)
5 axles[3]	200 (68.0)	100 (65.8)	122 (78.7)	125 (79.6)	202 (58.1)	161 (64.4)	122 (78.7)	1032 (68.3)
6 axles	19 (6.5)	5 (3.3)	5 (3.2)	7 (4.5)	72 (20.7)	55 (22.0)	29 (18.0)	192 (12.7)
7 axles	41 (14.0)	37 (24.3)	21 (13.6)	17 (10.8)	16 (4.6)	10 (4.0)	2 (1.3)	144 (9.5)
8 axles	20 (6.8)	1 (0.7)	3 (1.9)	5 (3.2)	6 (1.7)	6 (2.4)	0 (0.0)	41 (2.7)
9 axles	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	1 (0.4)	0 (0.0)	2 (0.1)
2 axle tractors+ 1 axle trailers	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.8)	0 (0.0)	2 (0.1)
2 axle tractors+ 2 axle trailers	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	9 (2.6)	14 (5.6)	2 (1.3)	25 (1.7)
Total	294 (100)	152 (100)	155 (100)	157 (100)	348 (100)	250 (100)	155 (100)	1511 (100)

1--Three-axle straight trucks
2--Three-axle tractors + one-axle trailers
3--Three-axle tractors + two-axle trailers

Where the brake condition is tabulated by province, the results are also differentiated according to whether the inspections were conducted by provincial inspectors or the contractor's mechanic. As will be seen in the tabulations, the brake outages for vehicles inspected by the contractor's mechanic were substantially and consistently lower than those reported by provincial inspectors. An analysis of the data obtained from the only site (Oakville, Ontario) that involved both a provincial inspector and the contractor's mechanic has indicated that the differences in their observations are statistically significant (see Appendix C). That analysis suggests that the contractor's mechanic consistently underreported the outage rate of the brakes that he inspected. This difference must be borne in mind in interpreting results for the purpose of making interprovincial comparisons.

3.2 Brakes on Front Axles

3.2.1 All Vehicles

Table 4 shows the incidence of fitment of front-axle brakes for all 1511 heavy trucks inspected in the survey. Over all, 46.3% of the vehicles were not equipped with front-axle brakes. In addition, about 1% of all vehicles, or about 2% of vehicles equipped with front brakes, were found to have had their front brakes disconnected. As expected, the vast majority, nearly 92%, of front brakes were of the S-cam type. Wedge brakes accounted for a further 7% of the front-axle brakes. Four vehicles, all found in Ontario, were equipped with twin-wedge front brakes. Only three vehicles had air-hydraulic brakes on the front axle.

Table 4 shows that the fitment rate was higher in the eastern and central provinces than in the western provinces. The highest was in Ontario, where slightly over 70% of the vehicles were equipped with front-axle brakes. Quebec's rate was second highest at 65.6%. Approximately half of the vehicles inspected in Saskatchewan, Manitoba, and New Brunswick were not equipped with front brakes, their non-fitment rates having been 49%, 51%, and 49.7%, respectively. Vehicles without front-axle brakes were found most often in two western-most provinces, 61.9% in British Columbia and 63.8% in Alberta. The proportion of vehicles with disconnected front brakes, though small over all, was highest in Manitoba (six vehicles) where there is a requirement for brakes on every axle of a vehicle.

Table 5 shows the incidence of fitment of front-axle brakes according to the ownership of the tractors or trucks. Trucking companies owned 65.2% of the surveyed vehicles; drivers owned 30.2%. Only 4.5% of the vehicles were leased. Nearly 60% of the vehicles owned by trucking companies were equipped with front-axle brakes. In contrast, only 37% of the vehicles owned by drivers were so equipped.

TABLE 4
FITMENT OF BRAKES ON FRONT AXLES (ALL VEHICLES)

Front axle brakes	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	Total in survey
Not Equipped	182 (61.9)	97 (63.8)	76 (49.0)	80 (51.0)	102 (29.3)	86 (34.4)	77 (49.7)	700 (46.3)
S-cam brakes	95 (32.3)	48 (31.6)	67 (43.2)	69 (43.9)	222 (63.8)	155 (62.0)	75 (48.4)	731 (48.4)
Equipped and dis-connected	3 (1.0)	1 (0.7)	4 (2.6)	6 (3.8)	1 (0.3)	1 (0.4)	0 (0.0)	16 (1.0)
Air-hydraulic brakes	0 (0.0)	1 (0.7)	0 (0.0)	0 (0.0)	2 (0.6)	0 (0.0)	0 (0.0)	3 (0.2)
Twin-wedge brakes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (1.1)	0 (0.0)	0 (0.0)	4 (0.3)
Wedge brakes	14 (4.8)	5 (3.3)	8 (5.2)	2 (1.3)	17 (4.9)	8 (3.2)	3 (1.9)	57 (3.8)
Total	294 (100)	152 (100)	155 (100)	157 (100)	348 (100)	250 (100)	155 (100)	1511 (100)

TABLE 5
FITMENT OF FRONT-AXLE BRAKES BY VEHICLE OWNERSHIP

Vehicle ownership	Fitment of front-axle brakes			Total
	Front brake equipped	Front brake disconnected	Front brake not equipped	
Owned by driver	169 (37.0)* (21.3)**	4 (0.9) (25.0)	284 (62.1) (40.6)	457 (30.2)
Leased	42 (61.8) (5.3)	0 (0.0) (0.0)	26 (38.2) (3.7)	68 (4.5)
Owned by driver's employer	584 (59.4) (73.4)	11 (1.1) (68.7)	389 (39.5) (55.6)	984 (65.2)
Ownership unknown	0 (0.0) (0.0)	1 (50.0) (6.3)	1 (50.0) (0.1)	2 (0.1)
Total	795 (52.6)	16 (1.1)	700 (46.3)	1511 (100)

*---Row percent
**---Column percent

It should be noted that, in the two cases where drivers refused to be interviewed, one vehicle had front brakes disconnected and the other was not equipped with front brakes.

Table 6 presents a breakdown of front-axle brakes by chamber size. In effective area, 73.6% of the front brakes had a chamber size of 20 sq. in., and 15.5% a chamber size of 24 sq. in. It will be seen in later sections that the vast majority (about 98%) of the brakes on all non-front axles had a chamber size of 30 sq. in. This disparity in chamber size means that most of the heavy trucks equipped with front brakes have less braking effort on the front axle (even when the brakes are fully operational) than on all other axles.

Tables 7 and 8 show the condition of S-cam brakes on all front axles, separately for left and right sides. Over all, 16.5% of the front-axle brakes were either out of adjustment or inoperative. The percentage of these ineffective brakes varied from province to province, being lowest in B.C. (5.3%) and highest in Manitoba (27.5%). It is interesting to note that B.C., despite having a high percentage of vehicles without front-axle brakes, also had the largest percentage of front brakes in adjustment. The average front brake outage for vehicles inspected by provincial inspectors was nearly 20%, while that reported for vehicles inspected by the contractor's mechanic was 14.7%.

Table 9 shows the condition of front-axle brakes with respect to vehicle ownership. Of the front-axle brakes on vehicles owned by trucking companies, 17.8% were either out of adjustment or inoperative, compared with 11.8% of vehicles owned by drivers. Thus, while driver-owners are less likely than owners of trucking companies to own a

TABLE 6
CHAMBER SIZE OF FRONT-AXLE BRAKES

Chamber size (sq. in.)	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	Total in survey
12	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.1)
16	1 (0.9)	13 (24.1)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	0 (0.0)	15 (1.9)
20	94 (86.3)	28 (51.8)	65 (86.7)	1 (1.4)	173 (70.6)	151 (92.7)	73 (93.6)	585 (73.6)
24	0 (0.0)	7 (13.0)	0 (0.0)	64 (90.2)	47 (19.2)	3 (1.8)	2 (2.6)	123 (15.5)
30	0 (0.0)	1 (1.8)	0 (0.0)	3 (4.2)	1 (0.4)	0 (0.0)	0 (0.0)	5 (0.6)
Unknown	14 (12.8)	5 (9.3)	10 (13.3)	2 (2.8)	23 (9.4)	9 (5.5)	3 (3.8)	66 (8.3)
Total	109 (100)	54 (100)	75 (100)	71 (100)	245 (100)	163 (100)	78 (100)	795 (100)

TABLE 7
BRAKE CONDITION FOR FRONT AXLES (ALL VEHICLES), LEFT SIDE

Brake Condition	Provincial inspectors				Contractor's mechanic					
	Alta.	Man.	Ont.	Total	Ont.	B.C.	Sask.	Que.	N.B.	Total
In Adjustment	39 (81.3)	50 (72.5)	112 (81.8)	201 (79.1)	73 (85.9)	90 (94.7)	57 (85.1)	123 (79.3)	64 (85.3)	407 (85.3)
Out of Adjustment	9 (18.7)	19 (27.5)	19 (13.9)	47 (18.5)	11 (12.9)	4 (4.2)	8 (11.9)	24 (15.5)	1 (1.3)	48 (10.1)
Inoperative	0 (0.0)	0 (0.0)	6 (4.3)	6 (2.4)	1 (1.2)	1 (1.1)	2 (3.0)	8 (5.2)	10 (13.4)	22 (4.6)
Total	48 (100)	69 (100)	137 (100)	254 (100)	85 (100)	95 (100)	67 (100)	155 (100)	75 (100)	477 (100)

TABLE 8
BRAKE CONDITION FOR FRONT AXLES (ALL VEHICLES), RIGHT SIDE

Brake Condition	Provincial inspectors				Contractor's mechanic					
	Alta.	Man.	Ont.	Total	Ont.	B.C.	Sask.	Que.	N.B.	Total
In Adjustment	41 (85.4)	50 (72.5)	115 (83.9)	206 (81.1)	73 (85.9)	90 (94.7)	57 (85.1)	123 (79.3)	64 (85.3)	407 (81.1)
Out of Adjustment	7 (14.6)	19 (27.5)	16 (11.7)	42 (16.5)	11 (12.9)	4 (4.2)	8 (11.9)	24 (15.5)	1 (1.3)	48 (10.1)
Inoperative	0 (0.0)	0 (0.0)	6 (4.4)	6 (2.4)	1 (1.2)	1 (1.1)	2 (3.0)	8 (5.2)	10 (13.4)	22 (4.6)
Total	48 (100)	69 (100)	137 (100)	254 (100)	85 (100)	95 (100)	67 (100)	155 (100)	75 (100)	477 (100)

TABLE 9
CONDITION OF FRONT BRAKES BY VEHICLE OWNERSHIP

Vehicle ownership	Condition of front-axle brakes				Brake outage, % (a+b)/c
		In	Out (a)	Inoperative (b)	Total (c)	
Owned by driver	Left	141	14	6	161	11.8
	Right	143	12	6	161	
Leased	Left	33	7	1	41	18.3
	Right	34	6	1	41	
Owned by driver's employer	Left	434	74	21	529	17.8
	Right	436	72	21	529	

heavy truck equipped with front-axle brakes, they appear to pay more attention to the front-axle brakes on vehicles so equipped. Compared to company-owned vehicles, leased vehicles had a slightly higher outage of front-axle brakes.

Table 10 distributes all surveyed vehicles and those equipped with front-axle brakes by model year, with a corresponding breakdown of front-brake condition. About 48% of all vehicles were two to three years old (model year 1984 and later); the same age group accounted for 57.9% of vehicles equipped with S-cam brakes on the front axles. About 14% of the front brakes on vehicles of model year 1984 and later were maladjusted or inoperative, while the corresponding brake outage for older vehicles was about 19.3%.

It is of interest to note from Table 10 that the proportion of the surveyed vehicles found in each model year declined gradually from 1979 to 1983 and then increased sharply in 1984. This phenomenon could be attributable partly to the economic recession that occurred in the early 1980s. Therefore, although the sample of 1511 vehicles in the survey is not representative in all respects, it at least bears some resemblance to the heavy-truck population in Canada in terms of vehicle age.

TABLE 10
CONDITION OF FRONT BRAKES BY MODEL YEAR

MODEL YEAR	ALL VEHICLES	VEHICLES WITH S-CAM FRONT BRAKES	CONDITION OF FRONT BRAKE			
			LEFT SIDE		RIGHT SIDE	
			IN	OUT*	IN	OUT*
87	6 (0.4)	3 (0.5)	3 (0.5)	0 (0.0)	3 (0.5)	0 (0.0)
86	219 (14.5)	132 (18.1)	118 (19.3)	14 (11.6)	118 (19.2)	14 (12.1)
85	295 (19.6)	174 (23.8)	144 (23.6)	31 (25.6)	147 (23.9)	28 (24.1)
84	203 (13.4)	113 (15.5)	97 (15.9)	16 (13.2)	98 (15.9)	15 (12.9)
83	50 (3.3)	28 (3.8)	23 (3.8)	5 (4.1)	24 (3.9)	4 (3.5)
82	76 (5.0)	44 (6.0)	34 (5.6)	10 (8.3)	34 (5.5)	10 (8.6)
81	118 (7.8)	52 (7.1)	44 (7.2)	8 (6.6)	44 (7.2)	8 (6.9)
80	121 (8.0)	56 (7.7)	47 (7.7)	9 (7.4)	46 (7.5)	10 (8.6)
79	172 (11.4)	63 (8.6)	51 (8.4)	12 (9.9)	52 (8.5)	11 (9.5)
78	65 (4.3)	26 (3.6)	16 (2.6)	10 (8.3)	16 (2.6)	10 (8.6)
77 or older	171 (11.3)	30 (4.1)	24 (3.9)	6 (5.0)	24 (3.9)	6 (5.2)
UNKNOWN	15 (1.0)	9 (1.2)	9 (1.5)	0 (0.0)	9 (1.4)	0 (0.0)
TOTAL	1511 (100)	731 (100)	610 (100)	121 (100)	615 (100)	116 (100)

*---Includes inoperative brakes

3.2.2 Three-axle Straight Trucks and Two-axle Tractors

As mentioned before, the purpose of obtaining a small sample of three-axle straight trucks and two-axle tractors in the survey was to determine whether any of the front brakes on these vehicles were missing or inoperative. Tables 11 and 12 show the incidence of fitment of front brakes for the sample of 61 three-axle straight trucks and 27 two-axle tractors, respectively. Only three vehicles, all straight trucks, were found not to have brakes equipped on the front axle. A further review of the vehicle forms showed that the three vehicles were of model year 1979 and older. Although the sample was small, it suggests that most, if not all, of the three-axle straight trucks and two-axle tractors built in recent years have brakes on their front axles. According to the truck manufacturers, front brakes are now standard equipment on all such vehicles.

Tables 13 and 14 show the front-brake condition for the 39 straight trucks equipped with S-cam brakes on the front axles. The average outage was 11.5%. Over two-thirds of these front brakes were inspected by provincial inspectors, who, incidentally, recorded all the maladjusted and inoperative brakes.

The 25 two-axle tractors with S-cam front brakes were all inspected by the contractor's mechanic, as shown in Tables 15 and 16. Their front brake outage was 12%.

TABLE 11
FRONT-BRAKE FITMENT ON
THREE-AXLE STRAIGHT TRUCKS

Front-brake fitment	B.C.	Alta.	Sask.	Man.	Ont.	Total in survey
Not Equipped	0 (0.0)	1 (14.3)	0 (0.0)	1 (100)	1 (2.4)	3 (4.9)
S-cam brakes	5 (45.5)	4 (57.1)	0 (0.0)	0 (0.0)	30 (73.2)	39 (63.9)
Air-hydraulic	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (4.9)	2 (3.3)
Twin Wedge	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	3 (7.3)	3 (4.9)
Wedge brakes	6 (54.5)	2 (28.6)	1 (100)	0 (0.0)	5 (12.2)	14 (23.0)
Total	11 (100)	7 (100)	1 (100)	1 (100)	41 (100)	61 (100)

TABLE 12
FRONT-BRAKE FITMENT ON
TWO-AXLE TRACTORS

Front-brake fitment	Ont.	Que.	N.B.	Total in survey
S-cam brakes	9 (100)	14 (87.5)	2 (100)	25 (92.6)
Wedge brakes	0 (0.0)	2 (12.5)	0 (0.0)	2 (7.4)
Total	9 (100)	16 (100)	2 (100)	27 (100)

TABLE 13
FRONT-BRAKE CONDITION FOR THREE-AXLE STRAIGHT TRUCKS, LEFT SIDE

Brake Condition	Provincial inspectors		Contractor's mechanic		Total in survey
	Alta.	Ont.	Ont.	B.C.	
In Adjustment	3 (75.0)	19 (82.6)	7 (100)	5 (100)	34 (87.2)
Out of Adjustment	1 (25.0)	3 (13.0)	0 (0.0)	0 (0.0)	4 (10.2)
Inoperative	0 (0.0)	1 (4.4)	0 (0.0)	0 (0.0)	1 (2.6)
Total	4 (100)	23 (100)	7 (100)	5 (100)	39 (100)

TABLE 14
FRONT-BRAKE CONDITION FOR THREE-AXLE STRAIGHT TRUCKS, RIGHT SIDE

Brake Condition	Provincial inspectors		Contractor's mechanic		Total in survey
	Alta.	Ont.	Ont.	B.C.	
In Adjustment	3 (75.0)	20 (87.0)	7 (100)	5 (100)	35 (89.7)
Out of Adjustment	1 (25.0)	2 (8.7)	0 (0.0)	0 (0.0)	3 (7.7)
Inoperative	0 (0.0)	1 (4.3)	0 (0.0)	0 (0.0)	1 (2.6)
Total	4 (100)	23 (100)	7 (100)	5 (100)	39 (100)

TABLE 15
FRONT-BRAKE CONDITION FOR
TWO-AXLE TRACTORS,
LEFT SIDE

Brake Condition	Contractor's mechanic			Total in survey
	Ont.	Que.	N.B.	
In Adjustment	8 (88.9)	12 (85.7)	2 (100)	22 (88.0)
Out of Adjustment	1 (11.1)	0 (0.0)	0 (0.0)	1 (4.0)
Inoperative	0 (0.0)	2 (14.3)	0 (0.0)	2 (8.0)
Total	9 (100)	14 (100)	2 (100)	25 (100)

TABLE 16
FRONT-BRAKE CONDITION FOR
TWO-AXLE TRACTORS,
RIGHT SIDE

Brake Condition	Contractor's mechanic			Total in survey
	Ont.	Que.	N.B.	
In Adjustment	8 (88.9)	12 (85.7)	2 (100)	22 (88.0)
Out of Adjustment	1 (11.1)	0 (0.0)	0 (0.0)	1 (4.0)
Inoperative	0 (0.0)	2 (14.3)	0 (0.0)	2 (8.0)
Total	9 (100)	14 (100)	2 (100)	25 (100)

3.2.3 Three-axle Tractors

Table 17 shows the incidence of fitment of front brakes on three-axle tractors by province. The fitment rates for these vehicles are in general slightly lower than those calculated for all vehicles (see Table 4). Ontario has the highest fitment rate at 65.8%, and Alberta's the lowest at 33.1%. Over all, 49% of the three-axle tractors were not equipped with front brakes, and 1.1% had front brakes disconnected.

Tables 18 and 19 show the condition of the S-cam brakes on the front axles of the three-axle tractors. The highest brake outage was found in Manitoba at 27.5%, and the lowest in B.C. at 5.5%. For the brakes inspected by provincial inspectors, the outage was averaged at 19.8%, compared with 15.5% for those inspected by the contractor's mechanic.

Figure 1 shows a comparison of maladjusted and inoperative front brakes among the three types of power unit. Three-axle tractors had the highest front brake outage of 16.9%, compared to 11.5% for three-axle straight trucks, and 12% for two-axle tractors. It thus appears that the front brakes on the three-axle straight trucks and two-axle tractors were better maintained than those on the three-axle tractors.

Subsequent analyses for other vehicle variables and brake-related driver variables include no breakdown by power unit since, unlike the front-axle brakes, no other variables are expected to be correlated with the configuration of the power unit.

TABLE 17
FRONT BRAKE FITMENT ON THREE-AXLE TRACTORS

Front brake fitment	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	Total in survey
Not Equipped	182 (64.3)	96 (66.2)	76 (49.4)	79 (50.6)	101 (33.9)	86 (36.8)	77 (50.3)	697 (49.0)
S-cam brakes	90 (31.8)	44 (30.3)	67 (43.5)	69 (44.2)	183 (61.4)	141 (60.3)	73 (47.7)	667 (46.8)
Equipped and dis-connected	3 (1.1)	1 (0.7)	4 (2.6)	6 (3.9)	1 (0.3)	1 (0.4)	0 (0.0)	16 (1.1)
Air-hydraulic brakes	0 (0.0)	1 (0.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.1)
Twin-wedge brakes	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)	0 (0.0)	1 (0.1)
Wedge brakes	8 (2.8)	3 (2.1)	7 (4.5)	2 (1.3)	12 (4.0)	6 (2.5)	3 (2.0)	41 (2.9)
Total	283 (100)	145 (100)	154 (100)	156 (100)	298 (100)	234 (100)	153 (100)	1423 (100)

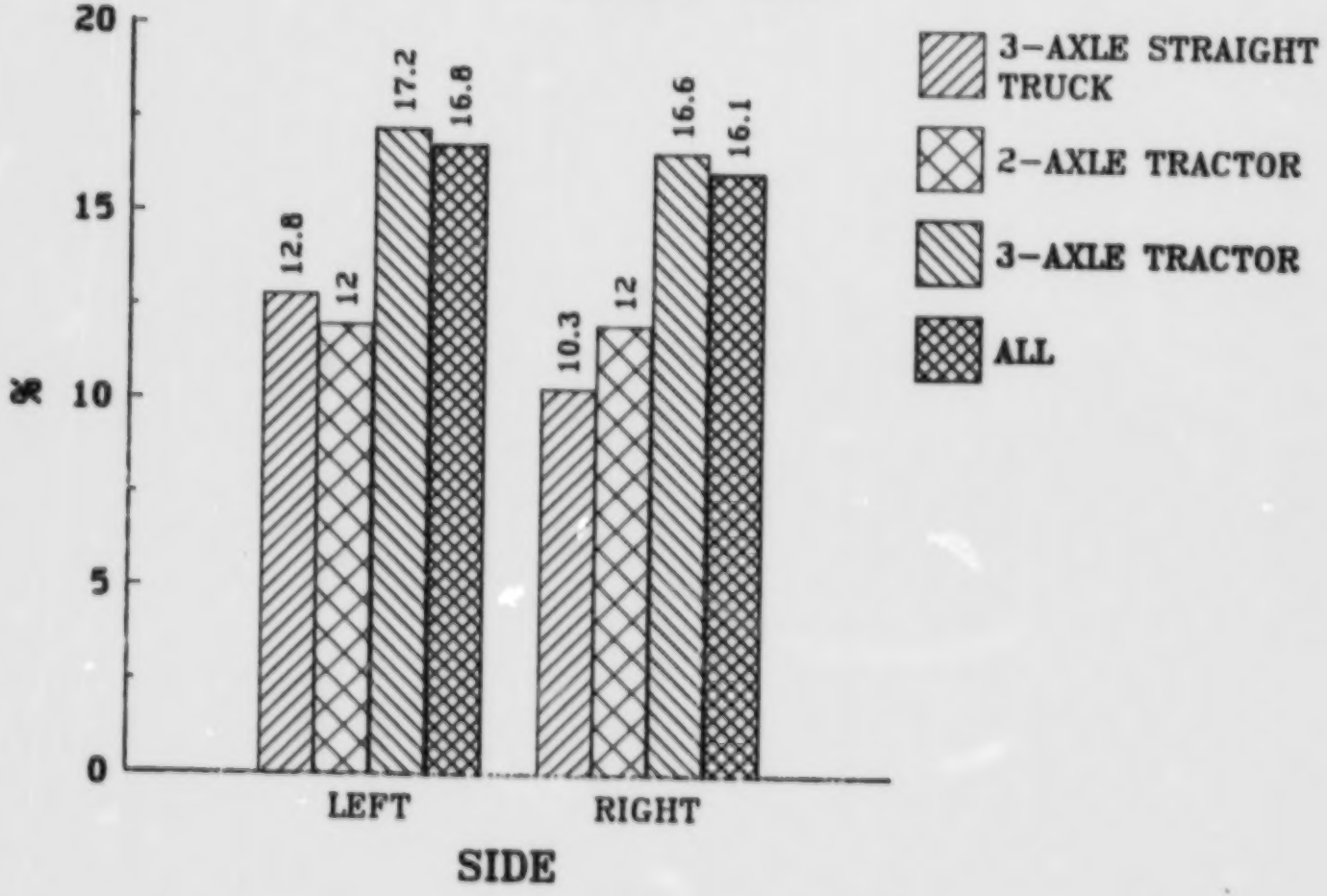
TABLE 18
FRONT-BRAKE CONDITION FOR THREE-AXLE TRACTORS, LEFT SIDE

Brake Condition	Provincial inspectors				Contractor's mechanic					
	Alta.	Man.	Ont.	Total	Ont.	B.C.	Sask.	Que.	N.B.	Total
In Adjustment	36 (81.8)	50 (72.5)	94 (82.5)	180 (79.3)	57 (82.6)	85 (94.5)	57 (85.1)	111 (78.7)	62 (84.9)	372 (84.5)
Out of Adjustment	8 (18.2)	19 (27.5)	15 (13.1)	42 (18.5)	11 (15.9)	4 (4.4)	8 (11.9)	24 (17.0)	1 (1.4)	48 (10.9)
Inoperative	0 (0.0)	0 (0.0)	5 (4.4)	5 (2.2)	1 (1.5)	1 (1.1)	2 (3.0)	6 (4.3)	10 (13.7)	20 (4.6)
Total	44 (100)	69 (100)	114 (100)	227 (100)	69 (100)	90 (100)	67 (100)	141 (100)	73 (100)	440 (100)

TABLE 19
FRONT-BRAKE CONDITION FOR THREE-AXLE TRACTORS, RIGHT SIDE

Brake Condition	Provincial inspectors				Contractor's mechanic					
	Alta.	Man.	Ont.	Total	Ont.	B.C.	Sask.	Que.	N.B.	Total
In Adjustment	38 (86.4)	50 (72.5)	96 (84.2)	184 (81.1)	57 (82.6)	85 (94.5)	57 (85.1)	111 (78.7)	62 (84.9)	372 (84.5)
Out of Adjustment	6 (13.6)	19 (27.5)	13 (11.4)	38 (16.7)	11 (15.9)	4 (4.4)	8 (11.9)	24 (17.0)	1 (1.4)	48 (10.9)
Inoperative	0 (0.0)	0 (0.0)	5 (4.4)	5 (2.2)	1 (1.5)	1 (1.1)	2 (3.0)	6 (4.3)	10 (13.7)	20 (4.6)
Total	44 (100)	69 (100)	114 (100)	227 (100)	69 (100)	90 (100)	67 (100)	141 (100)	73 (100)	440 (100)

FIGURE 1: COMPARISON OF MALADJUSTED AND INOPERATIVE FRONT BRAKES BY POWER UNIT



3.3 Brakes on Drive Axles

Table 20 shows the incidence of fitment of brakes on drive axles. Three vehicles were found to have no brakes on one of the tandem drive axles. Nearly 100% of drive axles were equipped with S-cam brakes. Only six axles, all tandem drives, had wedge brakes.

Table 21 shows that almost all drive-axle brakes (97.2%) had a chamber size of 30 sq. in. in effective area. Only a few of the brakes had chambers of smaller sizes, with 2.4% having 24 sq. in. and 0.1% having 20 sq. in. One vehicle was found to have air-disc brakes on its drive tandem.

Tables 22 and 23 show that the condition of drive-axle brakes was generally good, with an overall outage of 5.4%. Alberta had the highest percentage (15.3%) of drive-axle brakes out of adjustment, followed by Ontario (9.1%) and Manitoba (8.9%). The lowest brake outage was found in Saskatchewan, where only one brake was judged to be out of adjustment. A substantial difference in the reported outage for drive-axle brakes is apparent between vehicles inspected by provincial inspectors and those inspected by the contractor's mechanic. Provincial inspectors reported outages ranging from 8.9% in Manitoba to 15.3% in Alberta. In contrast, the contractor's mechanic reported outages ranging from an insignificant 0.2% in Saskatchewan to a high of only about 3% in B. C. and Ontario.

With respect to vehicle ownership, the pattern of brake outages for drive axles resembles that observed for the front axles, but with smaller percentages. Table 24 shows that the outage of drive-axle brakes was lowest at 4.4% for vehicles owned by drivers, compared with 5.8% for vehicles owned by trucking companies. Leased vehicles had the highest brake outage at 6.0%.

TABLE 20
FITMENT OF BRAKES ON DRIVE AXLES

Drive axle brakes	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	Total in survey
Not Equipped	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.3)	0 (0.0)	0 (0.0)	3 (0.1)
S-cam brakes	587 (99.8)	304 (100)	310 (100)	310 (98.7)	683 (99.4)	484 (100	308 (100)	2986 (99.7)
Wedge brakes	0 (0.0)	0 (0.0)	0 (0.0)	4 (1.3)	2 (0.3)	0 (0.0)	0 (0.0)	6 (0.2)
Total	588 (100)	304 (100)	310 (100)	314 (100)	687 (100)	484 (100)	308 (100)	2995 (100)

TABLE 21
CHAMBER SIZE OF BRAKES ON DRIVE AXLES

Chamber size (sq. in.)	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	Total in survey
20	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.6)	0 (0.0)	0 (0.0)	4 (0.1)
24	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	73 (10.6)	0 (0.0)	0 (0.0)	73 (2.4)
30	587 (100)	302 (99.3)	310 (100)	310 (98.7)	606 (88.5)	484 (100)	308 (100)	2907 (97.2)
Air-disc brakes	0 (0.0)	2 (0.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.1)
Unknown	0 (0.0)	0 (0.0)	0 (0.0)	4 (1.3)	2 (0.3)	0 (0.0)	0 (0.0)	6 (0.2)
Total	587 (100)	304 (100)	310 (100)	314 (100)	685 (100)	484 (100)	308 (100)	2992 (100)

TABLE 22
BRAKE CONDITION FOR DRIVE AXLES,
LEFT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	254 (83.6)	283 (91.3)	364 (87.9)	261 (97.0)	571 (97.3)	310 (100)	480 (99.2)	305 (99.0)	2828 (94.7)
Out of Adjustment	50 (16.4)	27 (8.7)	49 (11.8)	8 (3.0)	16 (2.7)	0 (0.0)	3 (0.6)	3 (1.0)	156 (5.2)
Inoperative	0 (0.0)	0 (0.0)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.2)	0 (0.0)	2 (0.1)
Total	304 (100)	310 (100)	414 (100)	269 (100)	587 (100)	310 (100)	484 (100)	308 (100)	2986 (100)

TABLE 23
BRAKE CONDITION FOR DRIVE AXLES,
RIGHT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	261 (85.9)	282 (91.0)	356 (86.0)	261 (97.0)	568 (96.8)	309 (99.7)	481 (99.4)	305 (99.0)	2823 (94.5)
Out of Adjustment	43 (14.1)	27 (8.7)	57 (13.8)	8 (3.0)	19 (3.2)	1 (0.3)	3 (0.6)	3 (1.0)	161 (5.4)
Inoperative	0 (0.0)	1 (0.3)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.1)
Total	304 (100)	310 (100)	414 (100)	269 (100)	587 (100)	310 (100)	484 (100)	308 (100)	2986 (100)

TABLE 24
CONDITION OF DRIVE-AXLE BRAKES BY VEHICLE OWNERSHIP

Vehicle ownership	Condition of drive-axle brakes				Total (c)	Brake outage, % (a+b)/c
	Side	In	Out (a)	Inoperative (b)		
Owned by driver	Left	869	42	1	912	4.4
	Right	874	38	0	912	
Leased	Left	125	8	0	133	6.0
	Right	125	8	0	133	
Owned by driver's employer	Left	1833	106	1	1940	5.8
	Right	1823	115	2	1940	

3.4 Brakes on Other Axles

Table 25 shows the incidence of fitment of brakes on all axles other than the front and drive axles. Six axles, on six different vehicles, were not equipped with any brakes. These were either air-lift axles or converter dolly axles. One axle, belonging to a trailer unit, was found to have brakes disconnected. The brakes found on these other axles were all of the S-cam type. Table 26 shows that 99.3% had a chamber size of 30 sq. in., and 0.7% a chamber size of 24 sq. in.

Tables 27 and 28 show the condition of the brakes on these other axles by province. The pattern of brake outage among the provinces was similar to that observed for the drive axles, but with significantly larger percentages. Alberta's was highest at 27.8%, followed by 14.5% in Manitoba and 14.3% in Ontario. Again, the lowest brake outage was in Saskatchewan, where only four trailer axles involving two vehicles were found to have inoperative brakes. Over all, the brake outage on other axles was 9.4%. For vehicles inspected by the contractor's mechanic, the reported brake outage was averaged at 3.6%, which again is substantially lower than the average of 21% reported by provincial inspectors.

TABLE 25
FITMENT OF BRAKES ON OTHER AXLES

Other axle brakes	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	Total in survey
Not Equipped	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)	5 (0.7)	0 (0.0)	0 (0.0)	6 (0.2)
S-cam brakes	724 (100)	370 (100)	361 (100)	365 (99.7)	732 (99.0)	594 (100)	343 (100)	3489 (99.7)
Equipped and dis-connected	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.3)	0 (0.0)	0 (0.0)	2 (0.1)
Total	724 (100)	370 (100)	361 (100)	366 (100)	739 (100)	594 (100)	343 (100)	3497 (100)

TABLE 26
CHAMBER SIZE OF BRAKES ON OTHER AXLES

Chamber size (sq. in.)	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	Total in survey
24	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	26 (3.6)	0 (0.0)	0 (0.0)	26 (0.7)
30	724 (100)	370 (100)	361 (100)	364 (4.3)	705 (96.4)	594 (100)	343 (100)	3461 (99.3)
Total	724 (100)	370 (100)	361 (100)	364 (100)	731 (100)	594 (100)	343 (100)	3487 (100)

TABLE 27
BRAKE CONDITION FOR OTHER AXLES,
LEFT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	277 (74.9)	313 (85.7)	334 (79.3)	293 (94.2)	708 (97.8)	357 (98.9)	557 (93.8)	334 (97.4)	3173 (91.0)
Out of Adjustment	91 (24.6)	51 (14.0)	79 (18.8)	16 (5.1)	12 (1.7)	0 (0.0)	33 (5.5)	9 (2.6)	291 (8.3)
Inoperative	2 (0.5)	1 (0.3)	8 (1.9)	2 (0.7)	4 (0.5)	4 (1.1)	4 (0.7)	0 (0.0)	25 (0.7)
Total	370 (100)	365 (100)	421 (100)	311 (100)	724 (100)	361 (100)	594 (100)	343 (100)	3489 (100)

TABLE 28
BRAKE CONDITION FOR OTHER AXLES,
RIGHT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	257 (69.5)	311 (85.2)	334 (79.3)	294 (94.5)	705 (97.4)	357 (98.9)	556 (93.6)	334 (97.4)	3148 (90.2)
Out of Adjustment	110 (29.7)	51 (14.0)	79 (18.8)	15 (4.8)	16 (2.2)	0 (0.0)	33 (5.6)	9 (2.6)	313 (9.0)
Inoperative	3 (0.8)	3 (0.8)	8 (1.9)	2 (0.6)	3 (0.4)	4 (1.1)	5 (0.8)	0 (0.0)	28 (0.8)
Total	370 (100)	365 (100)	421 (100)	311 (100)	724 (100)	361 (100)	594 (100)	343 (100)	3489 (100)

3.5 Brakes on All Axles

Tables 29 and 30 present a provincial breakdown of the condition of brakes on all axles considered together. The overall brake-outage pattern closely follows that observed for the dolly and trailer axles (Section 3.4), owing to the prevalence of trailer axles. Alberta had the highest brake outage at 21.8%. Ranking second and third were Manitoba with 13.4% and Ontario with 12.3%. These are the provinces in which professional inspectors were employed. As for the other four provinces, where the contractor's mechanic was used, none had an average brake outage higher than 6%. The difference between brake outages reported by provincial inspectors and those reported by the mechanic is especially striking for drive axles alone (12.5% vs 1.7%; see Section 3.3) and for dolly axles and trailers together (21% vs 3.6%; see Section 3.4). For the front-axle brakes, too, the difference is significant (20% vs 14.7%; see Section 3.2).

It is not clear how much of this discrepancy is attributable to variations, if any, in brake-maintenance practice among provinces. However, in Ontario alone, where the inspections were split about 40/60 between the contractor's mechanic and the provincial inspector, the difference in brake outages reported by the two was large enough (5.6% vs 16.9%) to suggest a difference in their methods of measuring push-rod travel. Furthermore, as shown in Appendix C, the analysis of brake data obtained at Oakville, the only site where both persons were involved in inspections, indicates that the difference in their reported brake outages is indeed statistically significant. It is probable that a considerable proportion of brakes reported by the contractor's mechanic as being in adjustment were in fact out of adjustment. In consequence of this underreporting of outages, it is likely that the overall

TABLE 29
BRAKE CONDITION FOR ALL AXLES,
LEFT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	570 (78.9)	646 (86.9)	810 (83.3)	627 (94.3)	1369 (97.3)	724 (98.1)	1160 (94.0)	703 (96.8)	6609 (91.7)
Out of Adjustment	150 (20.8)	97 (13.0)	147 (15.1)	35 (5.2)	32 (2.3)	8 (1.1)	60 (4.9)	13 (1.8)	542 (7.5)
Inoperative	2 (0.3)	1 (0.1)	15 (1.6)	3 (0.5)	5 (0.4)	6 (0.8)	13 (1.1)	10 (1.4)	55 (0.8)
Total	722 (100)	744 (100)	972 (100)	665 (100)	1406 (100)	738 (100)	1233 (100)	726 (100)	7206 (100)

TABLE 30
BRAKE CONDITION FOR ALL AXLES,
RIGHT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	559 (77.4)	643 (86.4)	805 (82.8)	628 (94.4)	1363 (96.9)	723 (98.0)	1160 (94.0)	703 (96.8)	6584 (91.4)
Out of Adjustment	160 (22.2)	97 (13.1)	152 (15.6)	34 (5.1)	39 (2.8)	9 (1.2)	60 (4.9)	13 (1.8)	564 (7.8)
Inoperative	3 (0.4)	4 (0.5)	15 (1.6)	3 (0.5)	4 (0.3)	6 (0.8)	13 (1.1)	10 (1.4)	58 (0.8)
Total	722 (100)	744 (100)	972 (100)	665 (100)	1406 (100)	738 (100)	1233 (100)	726 (100)	7206 (100)

survey results respecting brake condition underestimate the true condition of the air-brakes on highway trucks.

For different perspective of brake outages, Table 31 gives a breakdown by province and number of brakes out of adjustment per vehicle. A total of 376 vehicles, or 24.9%, were found to have at least one brake out of adjustment; about 90% of these 376 had two or more brakes out. The percentage of vehicles with brakes out varied considerably from province to province, with a high of 55.9% in Alberta and a low of 8.4% in Saskatchewan. The pattern of brake outage by vehicle is quite similar to that observed with respect to axles.

Of the vehicles inspected by provincial inspectors, 45% were found to have at least one brake out of adjustment or inoperative. For vehicles inspected by the contractor's mechanic, the corresponding outage was only 14.4%.

TABLE 31
NUMBERS OF MALADJUSTED AND INOPERATIVE BRAKES PER VEHICLE

No. of brakes out	Prov. insp.			Contractor's mechanic					TOTAL
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
0	67	105	113	115	265	142	194	134	1135
1	13	6	12	0	8	1	1		41
2	19	26	34	13	13	10	42	19	176
3	11	1	7	1			1		21
4	20	5	23	8	5	2	9	2	74
5	8		4						12
6	4	5	7	1			2		19
7	3		2						5
8	4	6	5	1	2				18
10	2	1	2		1		1		7
14	1	1							2
16		1							1
# of veh. with brakes out	85	52	96	24	29	13	56	21	376
% of veh. with brakes out	55.9	33.1	45.9	17.3	9.9	8.4	22.4	13.5	24.9
TOTAL	152	157	209	139	294	155	250	155	1511

3.6 Comparison of Brake Condition by Axle Group

Figures 2 and 3 compare maladjusted and inoperative brakes among the three groups of axles. With a few exceptions, drive axles generally had the lowest brake outage, and front axles the highest. The overall brake outage was 16.5% for the front axles, 5.4% for the drive axles, and 9.4% for the other axles. These percentages indicate that drive-axle brakes were the best maintained among all axle groups, whereas front-axle brakes received the least attention from the operators in inspection and maintenance. Most truck drivers dislike front-axle brakes and, accordingly, pay little attention to their condition. Further, drivers of combination vehicles are likely to be less inclined to take good care of the trailer-axle brakes, since trailers are used interchangeably in line-haul operation.

A somewhat different brake outage pattern was observed for vehicles surveyed in Alberta and for those inspected by the provincial inspector in Ontario. Their brake outage percentages were highest for the dolly and trailer axles and lowest for drive axles. The high brake outage in Alberta means that one-fifth of all heavy-truck brakes and over one-quarter of all the brakes on the dolly and trailer axles were out of adjustment.

FIGURE 2: COMPARISON OF MALADJUSTED AND INOPERATIVE BRAKES BY AXLE GROUP, LEFT SIDE

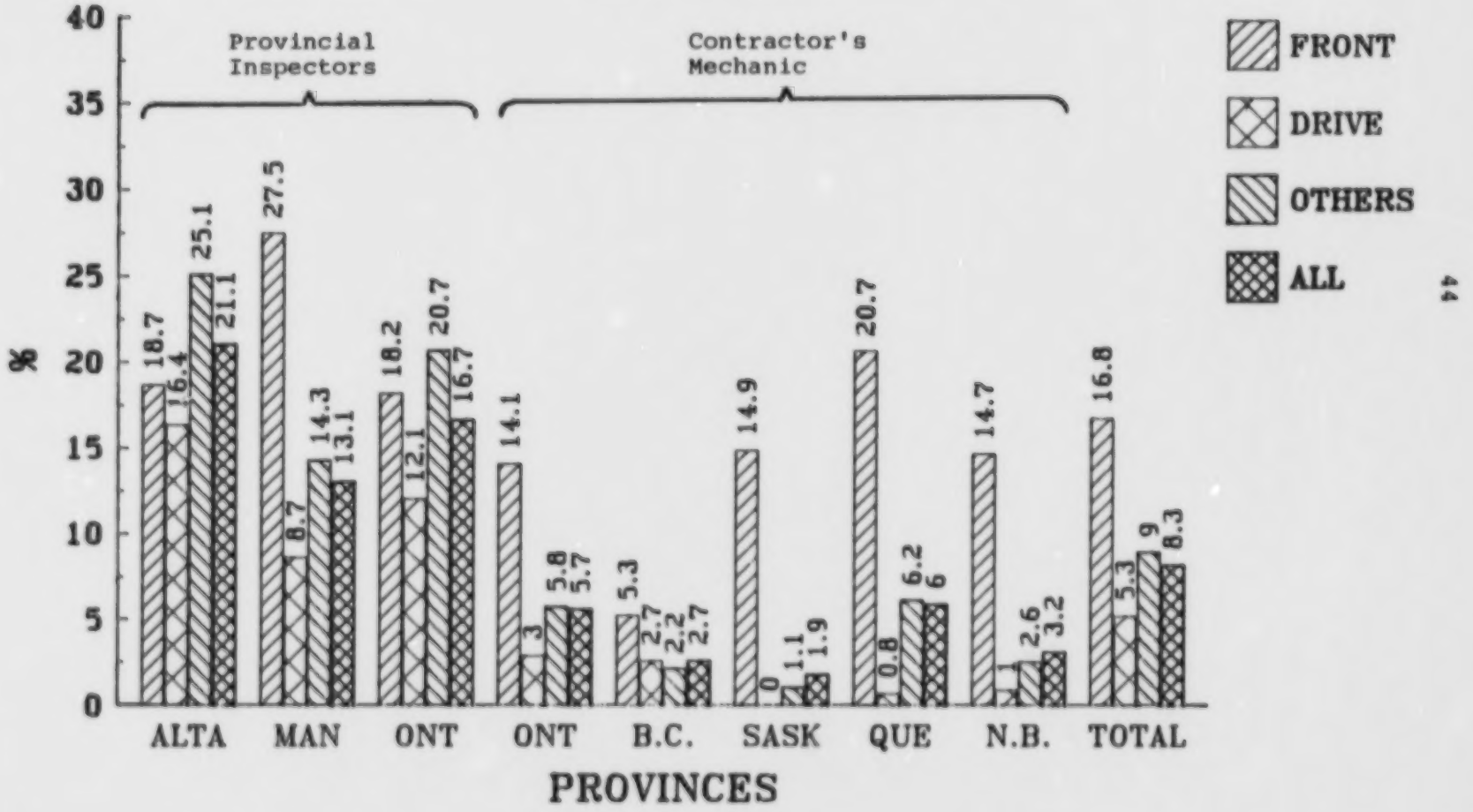
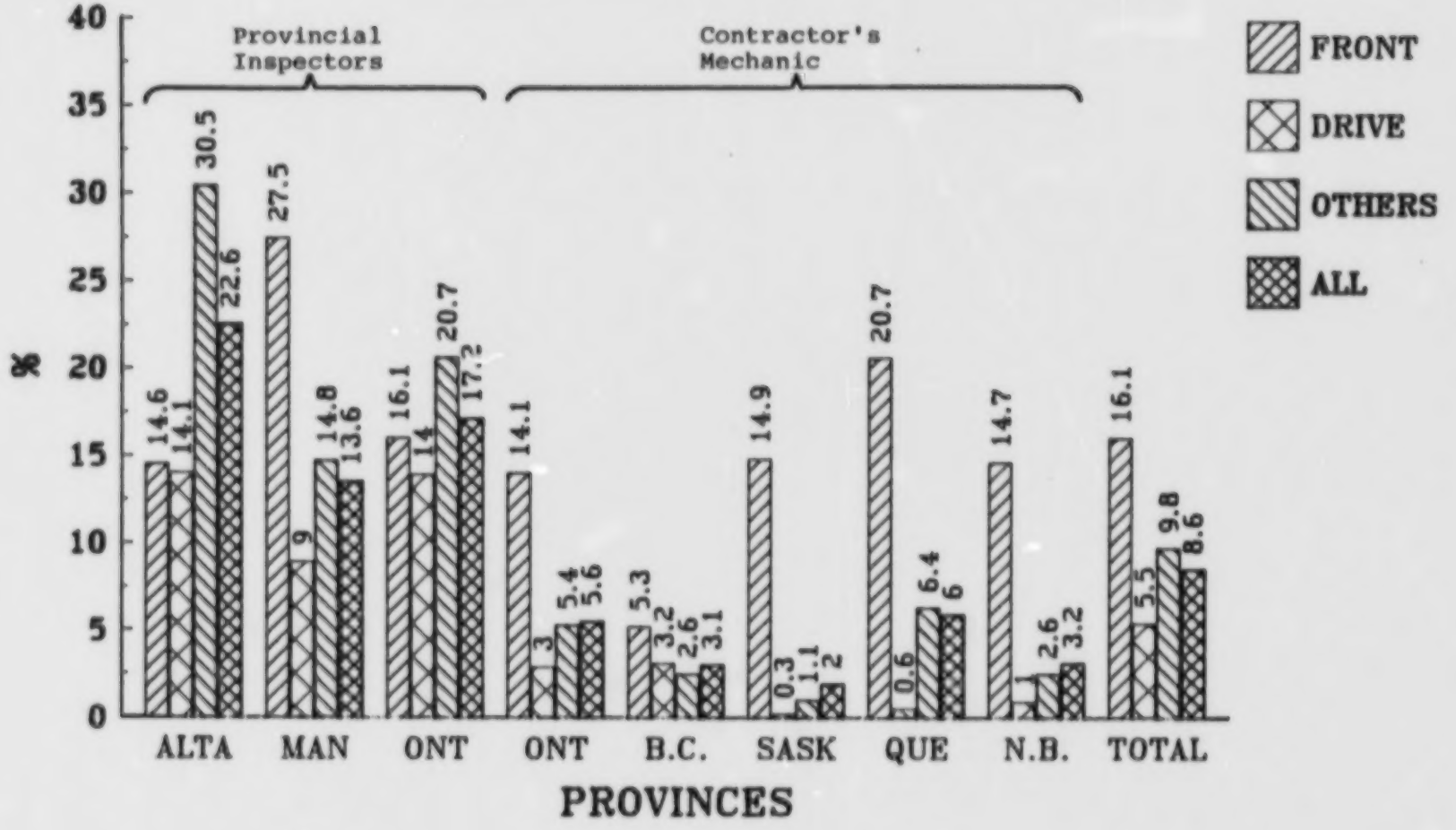


FIGURE 3: COMPARISON OF MALADJUSTED AND INOPERATIVE BRAKES BY AXLE GROUP, RIGHT SIDE



3.7 Automatic Slack Adjusters

The survey found that the use of automatic slack adjusters (ASA) was very uncommon. Table 32 shows that only 92 vehicles, about 6.1% of the 1511 in the survey, were found to have ASA installed on one or more axles. A total of 356 axles were fitted with ASA, amounting to 4.9% of all 7276 axles equipped with brakes. British Columbia had the largest share of ASA, equipped on 29 vehicles (9.9%) and 135 axles (9.5%).

Table 33 presents a breakdown of the ASA-equipped vehicles by axle numbers and the locations in which the ASA were fitted. It can seen that ASA were fitted solely on articulated trucks. Vehicles having ASA were more likely to be fully equipped (if front axles were discounted) than partly equipped. Moreover, ASA were found more commonly on drive axles than on other axles.

A comparison of axles with and without ASA revealed an important fact. As Tables 34 to 37 show, axles equipped with ASA had a substantially lower brake outage than those not so equipped (1.7% vs 8.8%). It is of interest to note that all of the maladjusted and inoperative brakes on the ASA-equipped axles were found by the provincial inspector in Ontario. Although the sample size of ASA-equipped vehicles was small, it has illustrated that brakes equipped with ASA were more likely to be in adjustment than those not so equipped. It appears that ASA were effective in keeping brakes within acceptable operating limits. This also appears to be true for the front-axle brakes alone. Tables 38 and 39 show that the brake outage for front axles equipped with ASA was 5.2%, which is considerably lower than the corresponding average calculated for the brakes on all front axles.

TABLE 32
FITMENT OF AUTOMATIC SLACK ADJUSTERS
AND THEIR BRAKE CONDITION

Front brake	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	Total
No. of veh. equipped with ASA on one or more axles	29	2	4	22	23	10	2	92
No. of brakes "in" for axles with ASA	270	22	32	160	132	68	16	700
No. of brakes "out" for axles with ASA	0	0	0	0	12	0	0	12

TABLE 33
ASA LOCATION ON EQUIPPED VEHICLES

Number of axles	Axle location with ASA	Number of vehicles
5	1	2
	2	1
	5	1
	2,3	8
	4,5	8
	1,2,3	9
	2,3,4,5	15
	1,2,3,4,5	20
6	2,3	2
	4,6	1
	5,6	1
	4,5,6	5
	1,2,3,4,6	1
7	1,2,3	1
	4,5,6	1
	5,6,7	1
	2,3,4,5,6,7	4
	1,2,3,4,5,6,7	5
8	2,3,4,5,6,7,8	5
two-axle tractor + one-axle trailer	1,2	1
	Total	92

TABLE 34
BRAKE CONDITION FOR ASA-EQUIPPED AXLES, LEFT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	11 (100)	80 (100)	33 (84.6)	33 (100)	135 (100)	16 (100)	34 (100)	8 (100)	350 (98.3)
Out of Adjustment	0 (0.0)	0 (0.0)	5 (12.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (1.4)
Inoperative	0 (0.0)	0 (0.0)	1 (2.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)
Total	11 (100)	80 (100)	39 (100)	33 (100)	135 (100)	16 (100)	34 (100)	8 (100)	356 (100)

TABLE 35
BRAKE CONDITION FOR ASA-EQUIPPED AXLES, RIGHT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	11 (100)	80 (100)	33 (84.6)	33 (100)	135 (100)	16 (100)	34 (100)	8 (100)	350 (98.3)
Out of Adjustment	0 (0.0)	0 (0.0)	5 (12.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (1.4)
Inoperative	0 (0.0)	0 (0.0)	1 (2.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.3)
Total	11 (100)	80 (100)	39 (100)	33 (100)	135 (100)	16 (100)	34 (100)	8 (100)	356 (100)

TABLE 36
BRAKE CONDITION FOR NON-ASA-EQUIPPED AXLES, LEFT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	559 (78.6)	566 (85.2)	777 (83.3)	594 (94.0)	1234 (97.1)	708 (98.1)	1126 (93.9)	695 (96.8)	6259 (91.4)
Out of Adjustment	150 (21.1)	97 (14.6)	142 (15.2)	35 (5.5)	32 (2.5)	8 (1.1)	60 (5.0)	13 (1.8)	537 (7.8)
Inoperative	2 (0.3)	1 (0.2)	14 (1.5)	3 (0.5)	5 (0.4)	6 (0.8)	13 (1.1)	10 (1.4)	54 (0.8)
Total	711 (100)	664 (100)	933 (100)	632 (100)	1271 (100)	722 (100)	1199 (100)	718 (100)	6850 (100)

TABLE 37
BRAKE CONDITION FOR NON-ASA-EQUIPPED AXLES, RIGHT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	548 (77.1)	563 (84.8)	772 (82.7)	595 (94.1)	1228 (96.6)	707 (97.9)	1126 (93.9)	695 (96.8)	6234 (91.0)
Out of Adjustment	160 (22.5)	97 (14.6)	147 (15.8)	34 (5.4)	39 (3.1)	9 (1.3)	60 (5.0)	13 (1.8)	559 (8.2)
Inoperative	3 (0.4)	4 (0.6)	14 (1.5)	3 (0.5)	4 (0.3)	6 (0.8)	13 (1.1)	10 (1.4)	57 (0.8)
Total	711 (100)	664 (100)	933 (100)	632 (100)	1271 (100)	722 (100)	1199 (100)	718 (100)	6850 (100)

TABLE 38
BRAKE CONDITION FOR FRONT AXLES
EQUIPPED WITH ASA,
LEFT SIDE

Brake Condition	Provincial inspectors			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	1 (100)	10 (100)	4 (66.6)	5 (100)	7 (100)	1 (100)	7 (100)	2 (100)	37 (94.9)
Out of Adjustment	0 (0.0)	0 (0.0)	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.6)
Inoperative	0 (0.0)	0 (0.0)	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.6)
Total	1 (100)	10 (100)	6 (100)	5 (100)	7 (100)	1 (100)	7 (100)	2 (100)	39 (100)

TABLE 39
BRAKE CONDITION FOR FRONT AXLES
EQUIPPED WITH ASA,
RIGHT SIDE

Brake Condition	Provincial inspector			Contractor's mechanic					Total in survey
	Alta.	Man.	Ont.	Ont.	B.C.	Sask.	Que.	N.B.	
In Adjustment	1 (100)	10 (100)	4 (66.6)	5 (100)	7 (100)	1 (100)	7 (100)	2 (100)	37 (94.9)
Out of Adjustment	0 (0.0)	0 (0.0)	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.6)
Inoperative	0 (0.0)	0 (0.0)	1 (16.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.6)
Total	1 (100)	10 (100)	6 (100)	5 (100)	7 (100)	1 (100)	7 (100)	2 (100)	39 (100)

3.8 Driver Awareness of Front-Brake Fitment

One of the brake-related questions in the driver interviews sought to determine drivers' awareness of the fitment of front-axle brakes on their trucks. Four driver responses were possible: (a) brakes equipped and connected; (b) brakes equipped but not connected; (c) brakes not equipped; and (d) don't know. Table 40 shows a cross-tabulation of the driver responses against the actual fitment of brakes on the front axles. Most of the drivers (about 88%) gave correct answers about the front brake fitment on their vehicles. However, of the 801 drivers who said their vehicles had front brakes equipped and connected, 87 were wrong because front brakes were either not equipped or disconnected. On the other hand, of the 664 drivers who replied that front brakes were not present, 51 were wrong because their vehicles were in fact equipped with front-axle brakes. Also, 21 drivers reported that their front brakes were equipped but not connected, but 11 of them were wrong because front brakes were either not equipped or equipped with measurable strokes. Further, 23 drivers expressed uncertainty about the fitment of front-axle brakes on their vehicles. The incorrect and unsure answers accounted for 11.4% of the driver responses.

Table 41 presents a breakdown of driver responses on front-brake fitment according to vehicle ownership. Incorrect or unsure answers came from 12.9% of the driver-employees and 7.9% of driver-owners. Of this small percentage of driver-owners, it is uncertain how many were actually ignorant of the front-brake fitment on their vehicles, and how many consciously provided wrong answers. Among the drivers who answered incorrectly, 20% reported that they owned the vehicles. Of the 23 drivers who reported no knowledge of front-brake fitment, 6 were the owners of the vehicles they were driving.

TABLE 40
DRIVER PERCEPTIONS VERSUS ACTUAL FITMENT OF FRONT BRAKES

DRIVER RESPONSE	FITMENT OF BRAKES ON FRONT AXLE				
	Brakes not equipped	Brakes Disconnected	Brakes Equipped	Brakes Inoperative	Total
Not equipped	606 (86.7)	7 (46.7)	49* (6.4)	2* (7.1)	664 (44.0)
Equipped but not connected	4* (0.6)	2 (13.3)	7* (0.9)	8 (28.6)	21 (1.4)
Equipped and connected	81* (11.6)	6* (40.0)	697 (90.9)	17 (60.7)	801 (53.1)
Don't know	8 (1.1)	0 (0.0)	14 (1.8)	1 (3.6)	23 (1.5)
Total	699 (100)	15 (100)	767 (100)	28 (100)	1509 (100)

*---Incorrect answers

TABLE 41
DRIVER RESPONSES ON FRONT-BRAKE FITMENT BY VEHICLE OWNERSHIP

VEHICLE	DRIVER ANSWER			
	RIGHT ANSWER ON FRONT-BRAKE FITMENT	WRONG ANSWER ON FRONT-BRAKE FITMENT	DON'T KNOW	TOTAL
OWNED BY DRIVER	421 (31.5)* (92.1)**	30 (20.0) (6.6)	6 (26.1) (1.3)	457 (30.3) (100)
LEASED	59 (4.4) (86.8)	8 (5.5) (11.8)	1 (4.3) (1.4)	68 (4.5) (100)
OWNED BY EMPLOYER	857 (64.1) (87.1)	111 (74.5) (11.3)	16 (69.6) (1.6)	984 (65.2) (100)
TOTAL	1337 (100) (88.6)	149 (100) (9.9)	23 (100) (1.5)	1509 (100) (100)

*---Column percent
**---Row percent

3.9 Fitment of Pressure-Limiting Valves

It is generally believed that the majority of the heavy trucks equipped with front-axle brakes are also equipped with a control valve to limit the air pressure available to the brake chambers at the front axle. The presence of this valve, which is situated inside the cab so as to be controllable by the truck driver, could not be determined from the chassis inspection in the survey. In order to find out whether a truck had a pressure-limiting valve for the front brakes, a question about its fitment was included in the driver questionnaire. This question was asked only after the driver had reported the presence of front-axle brakes on the vehicle.

Table 42 shows the driver responses on the fitment of a pressure-limiting valve versus the actual fitment of front-axle brakes. Of the 822 drivers who responded affirmatively on front-brake fitment, 69.7% reported presence and 28.5% absence of pressure-limiting valves. Again, incorrect responses were given since 55 drivers reported presence of pressure-limiting valves whereas their vehicles were actually found not to be equipped with front-axle brakes. Based on the responses consistent with the actual fitment of front-axle brakes, it was estimated that at least 70% of the heavy trucks equipped with front brakes were also fitted with a pressure-limiting valve.

TABLE 42
DRIVER RESPONSES ON FITMENT OF PRESSURE-LIMITING VALVE VERSUS ACTUAL FRONT-BRAKE FITMENT

EQUIPPED WITH PRESSURE-LIMITING VALVE?	ACTUAL FITMENT OF BRAKES ON FRONT AXLE				
	Brakes not equipped	Brakes Disconnected	Brakes Equipped	Brakes Inoperative	Total
Yes	55*	4	505	9	573 (69.7)
No	26	4	191	13	234 (28.5)
Don't Know	2	0	7	1	10 (1.2)
Missing responses	2	0	1	2	5 (0.6)
Total	85	8	704	25	822 (100)

*---Incorrect answers

3.10 Importance of Inspecting Brakes Before the Trip

Several questions were included in the driver interview to determine whether the driver had made a vehicle inspection before the start of the trip and, if so, what was deemed the most important item to be checked during the pre-trip inspection. For the latter information, the interviewer's question provided a multiple choice of brakes, tires, fifth wheel, and "other", but only the most important item as chosen by the driver was recorded.

Table 43 shows the driver responses on the inspection item of highest importance and distributes them according to the number of brakes found to be maladjusted or inoperative on the vehicle. A total of 1392 drivers (92%) in the survey replied that they had performed a pre-trip inspection, but their responses on the most important inspection item varied: the most frequent choice was brakes (469 or 33.7%), followed by tires and wheels (304 or 21.8%), and lights (227 or 16.3%). A further 11.6% of drivers replied "all", presumably to include not only all items mentioned by the interviewer, but also everything else that should be checked before the trip. Such a response may indicate an inability on the part of the driver to judge the relative importance of vehicular items during a pre-trip inspection. "Fifth wheel" was cited least frequently as the most important item, although it was irrelevant in the case of a straight truck. The "Other" category elicited mention of miscellaneous items such as steering, valves, and hook-up.

For the 469 drivers who considered brake inspection most important, 96 or 20.5% of their vehicles had at least one brake out of adjustment and over half of the 96 had two brakes out.

TABLE 43
DRIVER RESPONSES ON MOST IMPORTANT INSPECTION ITEM, DISTRIBUTED BY NUMBER OF BRAKES OUT

No. of brakes "out" on the veh.	Most important item in pre-trip inspection								Total
	Brakes	Tires and Wheels	Fifth Wheel	Lights	Oil, Fluid, Grease	Air	All	Others	
0	373	225	11	173	81	27	114	45	1049
1	13	8	0	6	4	0	6	0	37
2	49	36	1	26	22	2	17	12	165
3	4	6	0	2	3	0	2	0	17
4	15	14	0	11	6	5	10	4	65
5	5	1	0	0	1	0	2	0	9
6	3	6	0	3	2	0	3	1	18
7	1	2	0	0	0	0	1	0	4
8	5	3	0	4	0	4	2	0	18
10	1	2	0	1	0	0	3	0	7
14	0	0	0	1	0	0	1	0	2
16	0	1	0	0	0	0	0	0	1
Total	469 (33.7)	304 (21.8)	12 (0.9)	227 (16.3)	119 (8.5)	38 (2.7)	161 (11.6)	62 (4.6)	1392 (100)

3.11 Driver Preferences and Opinions Regarding Use of Front-Axle Brakes

The driver questionnaire contained several questions to elicit drivers' opinions on the use of front-axle brakes. First, the drivers were asked whether they preferred to drive heavy trucks with or without front-axle brakes. Then they were asked to provide a best reason against and a best reason for the use of front-axle brakes.

Table 44 presents a breakdown of the reasons cited against the use of front brakes, according to drivers' preferences for or against driving a heavy truck equipped with front-axle brakes. Not surprisingly, the majority of the drivers (71.7%) preferred driving a truck without front-axle brakes. Responses indicated that most drivers were concerned about losing steering control of the vehicle through lockup of the front wheels on application of front braking. More than half of the respondents (52.8%) indicated that front brakes were undesirable for driving in rain or on wet roads. In addition, "front-wheel lockup" and "loss of steering control" were cited, respectively, by 4.7% and 5.1% of drivers as the prime reason against front-brake use. "Undesirable on icy roads" was cited in 0.9% of the driver responses. A further 1.1% of drivers believed that front braking would caused jackknifing, and 2.2% responded that vehicle stability would be degraded. Other reasons cited by the drivers included "weight", "hills/mountains", "skidding", and "off-roads". However, 31.9% of drivers could not provide any reason for not using front-axle brakes. Among the drivers who preferred driving a truck equipped with front brakes, the percentage giving no reason for not using them was even higher at 68.3%, which amounts to 20% of all the drivers interviewed.

TABLE 44
REASONS AGAINST USE OF FRONT-AXLE BRAKES, ACCORDING TO DRIVER PREFERENCE

Driver's reason against the use of front brakes	Preference for driving a truck with or without front brakes		
	With	Without	Total
Degrading stability	8 (1.9)	25 (2.3)	33 (2.2)
Losing steering control	7 (1.7)	70 (6.5)	77 (5.1)
Don't know	291 (68.3)	190 (17.5)	481 (31.9)
Causing front-wheel lockup	15 (3.5)	55 (5.1)	70 (4.7)
Causing jack-knifing	2 (0.5)	15 (1.4)	17 (1.1)
Undesirable in rain or on wet roads	87 (20.4)	708 (65.5)	795 (52.8)
Undesirable on icy roads	10 (2.3)	4 (0.4)	14 (0.9)
Others	6 (1.4)	14 (1.3)	20 (1.3)
Total	426 (28.3)* (100)**	1081 (71.7) (100)	1507 (100) (100)

*---Row percent
**---Column percent

Table 45 distributes the driver responses on the best reason for using front-axle brakes according to driver preference. It appears that most drivers did not have a clear understanding of the advantages of front-axle brakes. The majority, 52.9% of all drivers, and an even higher percentage (65%) of those preferring a truck without front brakes, offered no reason for using front-axle brakes. The most obvious benefit of front braking--shorter stopping distance--was appreciated by only 44% of drivers. A very small percentage (1.7%) of the respondents noted that front brakes were desirable in bobtailing. Even fewer drivers believed that front brakes would improve the stability of the vehicle or reduce the probability of jackknifing.

Lastly, Table 46 presents a cross-tabulation of preference regarding front-axle brakes according to driver training. Only 28.5% of the respondents had taken a tractor-trailer driving course. Nearly 70% of such drivers preferred driving a truck without front brakes. It seems obvious that the advantages of front-axle brakes were seldom emphasized in the courses of driver training.

TABLE 45
REASONS FOR USE OF FRONT-AXLE BRAKES, ACCORDING TO DRIVER PREFERENCE

Driver's reason for the use of front brakes	Preference for driving a truck with or without front brakes		
	With	Without	Total
Shorter stopping distance	310 (72.8)	354 (32.8)	664 (44.0)
Better stability	9 (2.1)	3 (0.3)	12 (0.8)
Reducing jackknifing incidents	0 (0.0)	3 (0.3)	3 (0.2)
Don't know	94 (22.1)	703 (65.0)	797 (52.9)
Good when bobtailing	11 (2.6)	14 (1.3)	25 (1.7)
Others	2 (0.4)	4 (0.3)	6 (0.4)
Total	426 (28.3)* (100)**	1081 (71.7) (100)	1507 (100) (100)

*---Row percent
**---Column percent

TABLE 46
PREFERENCE REGARDING FRONT-AXLE BRAKES,
ACCORDING TO DRIVER TRAINING

Taken a tractor-trailer driving course?	Preference for driving a truck with or without front axle		Total
	With	Without	
Yes	129 (30.1)* (30.3)**	300 (69.9) (27.8)	429 (28.5)
No	297 (27.6) (69.7)	781 (72.4) (72.2)	1078 (71.5)
Total	426 (28.3)	1081 (71.7)	1507 (100)

*---Row percent
**---Column percent

4. CONCLUSIONS

1) Of all the vehicles inspected in the survey, 46.3% were not equipped with front-axle brakes. In addition, about 1% of the vehicles had front brakes disconnected. For the three-axle tractors alone, the non-fitment rate was 49%, with an additional 1.1% equipped but disconnected.

2) Among the provinces, the front-brake fitment rate was highest in Ontario (70.4%) and Quebec (65.2%), and lowest in B.C. (37.1%) and Alberta (35.5%). Approximately half of the vehicles inspected in Saskatchewan, Manitoba, and New Brunswick were not equipped with front-axle brakes.

3) The results of the analysis strongly suggest that brake-outage rates for vehicles inspected by the contractor's mechanic were significantly under-reported. Therefore, caution must be taken in comparing brake-outage rates among provinces.

4) For the vehicles inspected by provincial inspectors, the average outage of the front-axle brakes was 20%, with the highest rate found in Manitoba (27.5%) and the lowest in Alberta (16.6%). For the vehicles inspected by the contractor's mechanic, average front-brake outage reported was 14.7%, with the highest rate in Quebec (20.7%) and the lowest in B. C. (5.3%)

5) About 60% of the vehicles owned by trucking companies were equipped with front brakes, while only 37% of the vehicles owned by drivers were so equipped. However, 11.8% of the front brakes on driver-owned vehicles were out of adjustment, compared with 17.8% for company-owned vehicles.

6) Front-brake outage was 16.9% for three-axle tractors, 11.5% for three-axle straight trucks, and 12% for two-axle tractors.

7) With respect to axle group, brake outage was 16.5% for front axles, 5.4% for drive axles, and 9% for dolly axles and trailer axles.

8) Of all brakes inspected by provincial inspectors, 17.3% were out of adjustment or inoperative. The overall brake outage was only 3.9% for vehicles inspected by the contractor's mechanic.

9) About 45% of vehicles inspected by provincial inspectors had at least one brake out of adjustment or inoperative. The corresponding outage rate was only 14.4% for vehicles inspected by the contractor's mechanic.

10) Automatic slack adjusters were found on only 6.1% of all vehicles and 4.9% of all brake-equipped axles in the survey. Brakes with ASA had an outage rate of 1.7%, which is significantly lower than the 8.8% rate found for non-ASA brakes.

11) Of all drivers interviewed, 11.4% were wrong or did not know about the fitment of front-axle brakes on their vehicles.

12) An estimated 70% of vehicles equipped with front-axle brakes were also equipped with a pressure-limiting valve.

13) Of all drivers interviewed, 92% reported that they had made a pre-trip inspection of their vehicles. As to the most important inspection item, responses varied, with 33.7% choosing brakes, 21.8% tires and wheels, and 16.3% lights. Among drivers who considered brakes

most important, 20.5% of their vehicles had at least one brake out of adjustment, and over half of those had two brakes out.

14) About 71.7% of drivers preferred driving a heavy truck without front brakes. When asked why front brakes should not be used, 52.8% of drivers indicated rain or wet roads as the main concern, but 32% failed to provide an answer. On reasons in favour of front brakes, "shorter stopping distance" was cited by 44% of drivers, but 52.9% could not offer a reason.

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APPENDIX 'A'

Vehicle Inspection Form

VEHICLE INSPECTION FORM

ID NO.

	VAN	TANK	FLAT	OTHER	HUBODOMETER	
POWER UNIT	X	X	X	X		KM/MI
TRLR						KM/MI
TRLR						KM/MI

POWER UNIT

MAKE _____

MODEL _____

YEAR _____

ODOMETER _____ KM/MI

AXLE WEIGHTS (KG/LB)

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

REMARKS - SEE OVER

	LEFT					FRONT					RIGHT			
	MAXI BRAKE	ASA FITTED	MFR.	STATUS	STROKE (IN.)	CHAMBER SIZE (IN.²)	CHAMBER SIZE (IN.²)	STROKE (IN.)	STATUS	MFR.	ASA FITTED	MAXI BRAKE
1		Y N	R B OTH ___	I M O					I M O	R B OTH ___	Y N	
2	Y N	Y N	R B OTH ___	I M O					I M O	R B OTH ___	Y N	Y N
3	Y N	Y N	R B OTH ___	I M O					I M O	R B OTH ___	Y N	Y N
4	Y N	Y N	R B OTH ___	I M O					I M O	R B OTH ___	Y N	Y N
5	Y N	Y N	R B OTH ___	I M O					I M O	R B OTH ___	Y N	Y N
6	Y N	Y N	R B OTH ___	I M O					I M O	R B OTH ___	Y N	Y N

LEGEND

I - IN O - OUT
M - MARGINAL

R - ROCKWELL B - BENDIX

Y - YES N - NO

REMARKS _____

FOR A-TRAINS OR B-TRAINS

LEFT							FRONT					RIGHT	
7	Y N	Y N	R B OTH ___	I M O					I M O	R B OTH ___	Y N	Y N
8	Y N	Y N	R B OTH ___	I M O					I M O	R B OTH ___	Y N	Y N
9	Y N	Y N	R B OTH ___	I M O					I M O	R B OTH ___	Y N	Y N

APPENDIX 'B'

Driver Survey Form

DATE	TIME	INTERVIEWER	INSPECTOR	I.D. NO.

TRACTOR-TRAILER DRIVER SURVEY

We are conducting a study for Transport Canada to find out about the condition of front brakes and slack adjusters on tractor-trailers across Canada. The information will be used for research purposes only and will not be identified with you or the vehicle you are driving.

While the mechanic is inspecting your vehicle, I would like to ask you a few questions about your job for a separate Transport Canada survey. We want to collect information about tractor-trailer drivers and their attitudes towards their job. Your participation in the interview is voluntary. Your answers will be completely confidential and will not be identified with you in any way.

INTERVIEWER: CIRCLE THE APPROPRIATE NUMBER

1. Do you own the tractor that you are driving today, lease it or drive it for your employer?

   1 own
   2 lease
   3 employer
   4 other (specify) _____
   8 don't know
   9 refusal

2. Do you own the trailer that you are hauling today, lease it or drive it for your employer?

   1 own
   2 lease
   3 employer
   4 other (specify) _____
   8 don't know
   9 refusal

3. How many years have you been driving a tractor-trailer?

   1 less than a year
   2 1-2 years
   3 3-5 years
   4 5-10 years
   5 10 or more years
   8 don't know
   9 refusal

4. Have you ever taken a driver training course for tractor-trailers?

1	yes	
2	no	SKIP TO QUESTION 6
8	don't know	
9	refusal	

5. Was this course given by a community college, your employer or a private driving school?

1	community college	
2	employer	
3	private	
4	other	(specify) _____
8	don't know	
9	refusal	

6. About how far would you say that you have driven a tractor-trailer in the last 12 months?

1	less than 10,000 kms (6,250 mi)
2	10,000 - 24,999 kms (6,250 - 15,499 mi)
3	25,000 - 49,999 kms (15,500 - 30,999 mi)
4	50,000 - 99,999 kms (31,000 - 61,999 mi)
5	100,000 - 149,999 kms (62,000 - 92,999 mi)
6	150,000 kms - or more (93,000 mi or more)
8	don't know
9	refusal

7. Where do you usually drive a truck?

1	only within this province	
2	only within Canada	
3	only within Canada and the United States	
4	other	(specify) _____
9	refusal	

Now I would like to ask you a few questions about the current trip you are making.

8. How far will you be driving to reach your destination from your starting location?

_____	kms
_____	miles
8	don't know
9	refusal

9. About how many hours of driving will it take you to travel to your destination from your starting location?

_____	hours
8	don't know
9	refusal

10. Did you do a pre-trip inspection before this trip?

1 yes
2 no
8 don't know
9 refusal

→ SKIP TO QUESTION 13

11. How long did it take you to do the pre-trip inspection?

____ hours
____ minutes
8 don't know
9 refusal

12. In your opinion, what is the most important part of the tractor-trailer that should be checked during a pre-trip insection?

1 brakes
2 tires
3 fifth wheel
4 other (specify) _____
8 don't know
9 refusal

Now I would like to ask you a few questions about the truck you are driving today.

13 A. Is the tractor equipped with front brakes and if so, are they connected?

1 equipped and connected
2 equipped but not connected
3 not equipped
8 don't know
9 refusal

→ SKIP TO QUESTION 14

13 B. Is the front brake system equipped with an air limiting valve?

1 yes
2 no
8 don't know
9 refusal

14. Would you prefer to drive a truck with front axle brakes or without front axle brakes?

1 with
2 without

15. In your opinion, are there any reasons why front axle brakes should <u>not</u> be fitted?

0 better stability
1 allows steering control
2 shorter stopping distance
3 prevents front wheel lock-up
4 prevents jack-knifing
5 other (specify) _____
8 don't know
9 refusal

16. In your opinion, are there any reasons why front axle brakes <u>should</u> be fitted?

1 shorter stopping distance
2 better stability
3 prevents jack-knifing
4 other (specify) _____
8 don't know
9 refusal

17. If you had a problem with the slack adjusters while you were on the road, do you think you would be able to correct the problem yourself?

1 yes
2 no
8 don't know
9 refusal

18. Since this time yesterday, how many hours have you been driving a truck?

_____ hours

19. Since this time last (GIVE DAY OF WEEK) how many hours have you driven a truck?

_____ hours

I now have a few questions about your usual patterns of driving a truck.

20. Normally, at what speed do you drive on a multi-lane divided highway on which the traffic is light, weather is fair and road conditions are good?

_____ kph or _____ mph

21. Slow drivers on the highway are a nuisance for everyone. What ways have you used to get a slow driver to move over and let you pass? CIRCLE ALL RESPONSES MENTIONED

1 flash lights
2 beep horn
3 drive closely behind
4 use gestures
5 other (specify) _____
6 none
8 don't know
9 refusal

22. How often do you wear a seat belt when you are driving a tractor-trailer?

1 never
2 some of the time
3 most of the time
4 always
8 don't know
9 refusal

23. How often do you have difficulty staying alert when driving a truck?

1 never
2 very seldom
3 once in a while
4 quite often
8 don't know
9 refusal

24. Do you know any drivers who have been involved in accidents or had close-calls because they fell asleep at the wheel?

1 yes
2 no
8 don't know
9 refusal

25. Do you know any drivers who use stimulants other than coffee or tea to stay alert while driving a truck?

1 yes
2 no
8 don't know
9 refusal

26. In your opinion, is driving a truck under the influence of alcohol a frequent or infrequent practice among truck drivers?

1 frequent
2 infrequent
8 don't know
9 refusal

27. For example, how many out of 100 truck drivers do you think drive regularly while under the influence of alcohol?

_____ out of 100
888 don't know
999 refusal

28. And how many out of 100 truck drivers do you think are heavy drinkers while off the job?

_____ out of 100
888 don't know
999 refusal

29. How many traffic violations have you had in the past 3 years while driving <u>any</u> type of vehicle?

_____

30. In your opinion, what is the major problem in operating a tractor-trailer today?

1 long hours
2 car drivers
3 poor roads
4 government regulations
5 boredom
6 other (specify) _____
8 don't know
9 refusal

31. How old were you on your last birthday?

_____ years

32. INTERVIEWER: OBSERVE DRIVER'S SEX

male female

33. INTERVIEWER: OBSERVE SEATBELT USE

1 fastened
2 unfastened
3 unable to observe

APPENDIX 'C'

Analysis of Brake Condition Data

Obtained from Oakville Site

Analysis of Brake Condition Data Obtained from Oakville Site

There were 153 vehicles surveyed at this site. According to the records, 99 vehicles involving 482 brakes were inspected by the provincial inspector, and 54 vehicles involving 256 brakes were inspected by the contractor's mechanic. Their observations of brake condition are shown in the following table:

Brake condition	Number of brakes inspected		Total
	Contractor's Mechanic	Provincial Inspector	
In adjustment	246	416	662
Out of adjustment	7	56	63
Inoperative	3	10	13
Total	256	482	738

A chi-squared test shows that $x^2 = 18.09$ ($P < .005$), meaning that the differences are statistically significant.